**Center Innovation Fund: GSFC CIF**

# Phase Fresnel Lens Nanofabrication

Completed Technology Project (2015 - 2016)

## Project Introduction

Using NASA APRA and internal GSFC funding, PFLs have been fabricated using MEMS techniques at both UMCP and GSFC and have been characterized to have nearly diffraction-limited imaging, ~14 milli-arcseconds in the best case. Initial work was also completed by using a PFL and refractive component to produce an acromat that significantly extended the X-ray bandwidth of the imaging. However, MEMS fabrication is costly and time consuming, which makes prototyping new designs difficult. What is needed is a cost-effective and rapid fabrication technique to fabricate new PFL-based designs with improved performance and then characterize their performance at the GSFC 600-m Interferometry Testbed. The hot embossing technique (a micro-scale "off-set printing" approach) recently developed by Northeaster University offers this possibility. DELIVERABLE IN FY16: At least one Phase Fresnel Lens of design for an appropriate X-ray energy and focal length that can be characterized in the GSFC 600-m Interferometry Testbed.

## Anticipated Benefits

Heliophysics is also interested in using PFLs to perform high-angular resolution X-ray measurements of solar phenomena. PFLs have very long, 100 m -> >> km focal lengths (depending on X-ray energy and PFL diameter). Work is moving forward on developing formation-flying satellites (with N. Shah, Code 591) and we are part of a recently selected EPSCoR proposal (NMSU, PI institution) to develop a CubeSat mission to demonstrate formation flying and PFL imaging. Initial deliverable will be PFL(s) that will be characterized in the 600-m Interferometry Testbed. Based on these results, the NEU fabrication technique could be used to fabricate PFLs for the EPSCoR CubeSat mission.

The development of highly efficient and lightweight X-ray optics that image near the diffraction limit and over a wide energy range would be a transformational technical development.

Evaluating the NEU nanofabrication technique will allow NASA/GSFC to evaluate its potential in material engineering.

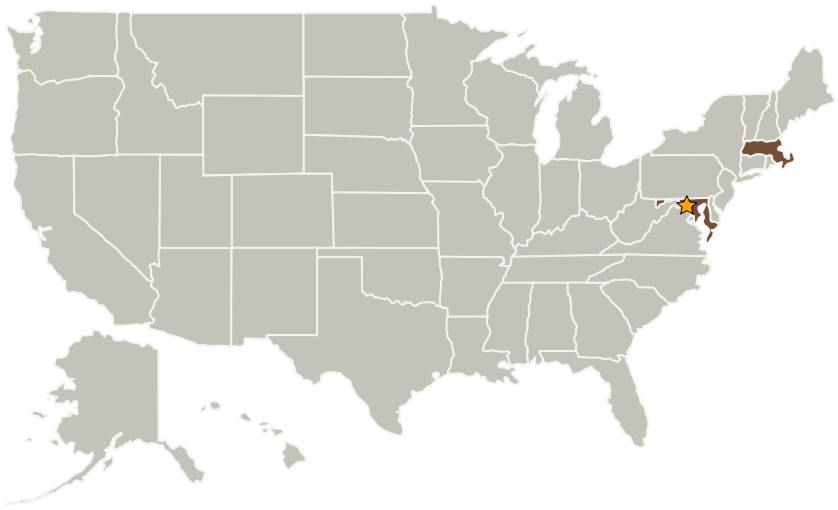
Phase Fresnel Lens Nanofabrication Project

## Table of Contents

# Phase Fresnel Lens Nanofabrication

Completed Technology Project (2015 - 2016)

## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Goddard Space Flight Center(GSFC) | Lead Organization | NASA Center | Greenbelt, Maryland |
| Northeastern University(NEU) | Supporting Organization | Academia | Boston, Massachusetts |

| Primary U.S. Work Locations | |
|---|---|
| Maryland | Massachusetts |

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Goddard Space Flight Center (GSFC)

**Responsible Program:**

Center Innovation Fund: GSFC CIF

## Project Management

**Program Director:**

Michael R Lapointe

**Program Manager:**

Peter M Hughes

**Principal Investigator:**

Takashi Okajima

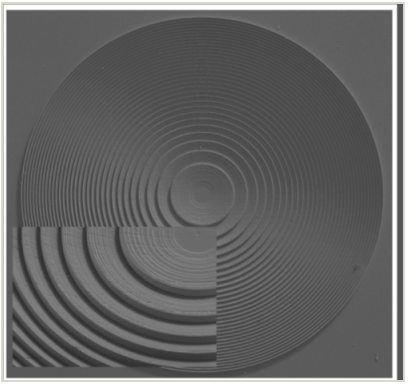
**Co-Investigators:**

John F Krizmanic
Mahmooda Sultana

# Phase Fresnel Lens Nanofabrication

Completed Technology Project (2015 - 2016)

## Images



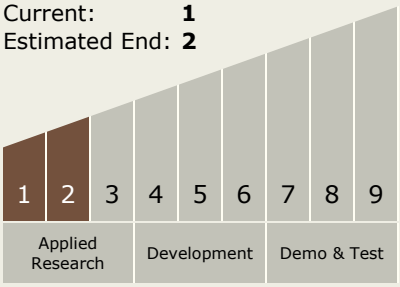
**Phase Fresnel Lens Nanofabrication Project**
Phase Fresnel Lens Nanofabrication Project
*(https://techport.nasa.gov/image/19319)*

## Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

## Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**




## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes